

What is claimed is:

1 1. A vehicle fleet management information system for fleet asset management by
2 enabling identification of location and direction of movement, if any, of each vehicle in said
3 fleet in real-time and to automatically communicate directly therewith for reporting of vehicle
4 location, direction and status of predetermined events in which the vehicle may become
5 engaged, said system comprising:

6 apparatus for broadcasting information to vehicles in the fleet over a communications
7 network in which each vehicle is a participant, with precise time synchronization of the
8 broadcast information according to timing employed in a navigation system for said fleet
9 relative to a stable reference point,

10 apparatus in each vehicle for detecting predetermined events of interest and reporting
11 information concerning vehicle location and said detected events to a fleet management office
12 over said communications network, and

13 said broadcast apparatus including apparatus for assigning each vehicle in the fleet a
14 unique time slot to transmit its reporting information without substantially interfering with
15 transmissions from other vehicles in their own respective time slots.

1 2. The fleet management information system of claim 1, wherein said broadcast
2 apparatus includes means for broadcasting via FM radio subcarrier.

1 3. The fleet management information system of claim 1, wherein said stable
2 navigation reference for position determination is a satellite Global Positioning System (GPS).

1 4. The fleet management information system of claim 1, wherein at least some of
2 said owners have low update rate requirements, and including means for polling vehicles
3 associated with low update rate owner requests for information, without need for entry of the
4 polled vehicle reporting transmissions into specific predetermined time slots of the network.

1 5. The fleet management information system of claim 4, wherein said low update
2 rate requests for owners providing emergency response services include means for varying their
3 respective vehicle position update rates in times of emergency.

1 6. The fleet management information system of claim 1, including a network
2 distribution center including means for providing space diversity processing of said received
3 vehicle data packets for recovery of possibly corrupted data.

1 7. The fleet management information system of claim 1, including means for
2 dynamically allocating slots to accommodate update rates of information according to different
3 periodic reporting intervals by different vehicles in the network.

1 8. The fleet management information system of claim 1, including means for
2 dynamically allocating slots to allow higher priority data packets to be transmitted to or from
3 vehicles before lower priority packets that were queued first.

1 9. The fleet management information system of claim 8, including means for
2 increasing the priority of delayed lower priority packets according to a predetermined
3 maximum time of delay.

1 10. The fleet management information system of claim 1, including means for
2 providing auxiliary reporting slots for vehicles to accommodate need for prompt reporting of
3 important information independent of slower periodic reporting intervals.

1 11. The fleet management information system of claim 1, including means for
2 inferring the identity of a reporting vehicle to accommodate need for prompt reporting of
3 important information independent of slower periodic reporting intervals.

1 **12.** The fleet management information system of claim 1, wherein said
2 communications network is a time division multiple access (TDMA) wireless network.

1 **13.** The fleet management information system of claim 12, wherein said broadcast
2 apparatus includes means for broadcasting via FM radio subcarrier, said stable navigation
3 reference for position determination is a satellite Global Positioning System (GPS), and said
4 FM radio subcarrier is used to broadcast synchronization data to all TDMA network
5 participants independent of separate delivery of time information from said GPS navigation
6 reference.

1 **14.** A management information system for a multiplicity of movable, information
2 communicating assets whether stationary or undergoing movement, to identify the location of
3 each asset in real-time and to communicate therewith, said system comprising:

4 apparatus for transmitting information to each of said assets via a communications
5 network in which each of said assets is a participant,

6 apparatus for receiving information transmitted by each of said assets via said
7 communications network,

8 apparatus for detecting the location of each asset relative to an arbitrary stable reference
9 point in a navigation system,

10 apparatus for precise time synchronization of information transmitted to each of said
11 assets with timing information derived from said navigation system, and

12 apparatus for assigning each of said assets a unique time slot in which to transmit
13 information to said receiving apparatus over said communications network without
14 substantially interfering with information transmissions by others of said assets in their
15 respective time slots.

1 15. A time division multiple access (TDMA) wireless network for real time
2 reporting of fleet vehicle locations and other information in data packets in respective assigned
3 time slots to a central data processing location on a UHF band, with a minimum of gaps
4 between reporting transmissions, said network comprising

5 means for precise time synchronization of all elements of said TDMA wireless network,
6 including wireless phase lock loop (PLL) timing control loop means for distributing a single,
7 remote global positioning satellite GPS based time reference throughout said network.

1 16. The TDMA wireless network of claim 15, including FM subcarrier broadcast
2 means having timing data referenced to a GPS based time source for broadcast to the fleet
3 vehicles.

1 17. The TDMA wireless network of claim 16, including means for providing
2 navigation data for the fleet vehicles by other than GPS.

1 18. The TDMA wireless network of claim 16, including means on each of said fleet
2 vehicles for receiving data requests and messages from said central station and other
3 information to synchronize said network elements without a GPS receiver.

1 19. The TDMA wireless network of claim 16, wherein said PLL timing control loop
2 means operates as an algorithm for synchronization of the different elements of the network to
3 a synchronization pattern, using said algorithm to eliminate variability in synchronization.

1 20. The TDMA wireless network of claim 19, including means for processing
2 difference in time from said GPS time reference and received synchronization data on said FM
3 subcarrier using said PLL algorithm to generate a timing correction.

1 **21.** A fleet management system for tracking the locations and paths of vehicles at
2 rest and in transit for management of dispatch and operation of said vehicles, comprising:
3 a radio frequency network,
4 a plurality of geographically disparate network hubs for communication with fleet
5 management offices and said vehicles over said network,
6 a tracking computer on each of said vehicles for developing and transmitting navigation
7 and status messages to at least one of said network hubs for communication to a fleet
8 management office responsible for the respective transmitting vehicle,
9 apparatus for establishing a protocol for entry by said tracking computers into the
10 network in assigned time slots for periodic transmission of messages by the respective tracking
11 computers, and
12 apparatus for providing space diversity of the messages received by said network hubs
13 from said tracking computers to avoid corruption of messages received from a single tracking
14 computer at more than one of said network hubs.

1 **22.** The fleet management system of claim 21, wherein said network is a time
2 division multiple access (TDMA) network.

1 **23.** The fleet management system of claim 21, wherein said protocol establishing
2 apparatus provides management of different periodic transmission intervals by different vehicles
3 in the network by dynamically allocating said slots for various update rates.

1 **24.** The fleet management system of claim 21, wherein said protocol establishing
2 apparatus provides auxiliary reporting slots to allow prompt reporting of important data by the
3 respective tracking computers independent of slower said periodic transmission intervals.

1 **25.** The fleet management system of claim 21, including apparatus for supporting
2 both guaranteed and non-guaranteed delivery of message data.

1 **26.** The fleet management system of claim 21, wherein said network includes a dual
2 band full-duplex interface with TDMA on one-half of said interface and broadcast on the other
3 half of said interface.

1 **27.** The fleet management system of claim 21, wherein said assigned slots are unique
2 to respective ones of said tracking computers, whereby to minimize bandwidth usage in said
3 network by enabling identity of the vehicle whose tracking computer is transmitting according
4 to the time slot in which the transmission is received.

1 **28.** A fleet management system for tracking the locations and paths of vehicles at
2 rest and in transit for management of dispatch and operation of said vehicles, comprising:
3 a wireless network,
4 apparatus for modulating broadcasts transmitted on said network with message data
5 including a synchronization pattern,
6 a plurality of geographically disparate network hubs for communication with fleet
7 management offices and said vehicles over said network,
8 a tracking computer on each of said vehicles for developing and transmitting navigation
9 and status messages to at least one of said network hubs for communication to a fleet
10 management office responsible for the respective transmitting vehicle, and
11 apparatus for synchronizing the timing of said tracking computers with each other and
12 with said network hubs by aligning respective internal clocks thereof to said synchronization
13 pattern pulses in received broadcasts of data on said network,
14 said synchronizing apparatus including a timing control for correcting drifts in the
15 timing to maintain synchronization between said tracking computers and said network hubs.

1 **29.** The fleet management system of claim 28, wherein said timing control comprises
2 a remote phase locked loop (PLL) that includes said apparatus for modulating broadcasts and

3 a network control center that receives broadcasts of data on said network and computes and
4 transmits a time correction to said apparatus for modulating broadcasts, to maintain said
5 synchronization.

1 **30.** The fleet management system of claim 29, wherein said network control center
2 includes a receiver for receiving Global Positioning System (GPS) satellite signals including a
3 GPS time reference and means for obtaining the difference between the average time of said
4 received synchronization pattern and the time of said received GPS time reference from which
5 to compute said time correction.

1 **31.** The fleet management system of claim 30, wherein said network includes a time
2 division multiple access (TDMA) network, and said timing control PLL includes means for
3 maintaining said synchronization in said TDMA network to about three microsecond accuracy.

1 **32.** The fleet management system of claim 28, wherein said timing control comprises
2 an RF link phase lock loop to maintain clock synchronization to a reference.

1 **33.** The fleet management system of claim 30, wherein said network includes a dual
2 band full-duplex interface with TDMA on one-half of said interface and broadcast on the other
3 half of said interface.

1 **34.** The fleet management system of claim 33, including a remote reference
2 controlled through a wireless link for synchronizing the TDMA portion of said network to GPS
3 time.

1 **35.** The fleet management system of claim 33, wherein each of said tracking
2 computers and said network hubs includes a central processing unit comprising a
3 microprocessor with a time processing unit for performing precise clock synchronization within

4 10 microseconds for the TDMA portion of said network.

1 36. The fleet management system of claim 28, including means for maintaining
2 synchronization between said tracking computers and said network hubs and to a
3 synchronization pattern, using the same algorithm to eliminate variability in synchronization.

1 37. An article management system for tracking the locations of articles at rest and
2 in transit for maintaining a desired flow of said articles, said system providing bandwidth
3 efficient wireless transceiver operation and comprising:

4 a plurality of data transmitters and a plurality of data receivers for communication via
5 a wireless network with respect to location of said articles,

6 means in each of said transmitters for filtering baseband data to reduce the occupied
7 bandwidth of the channel on which data is transmitted, including removal of synchronization
8 data to minimize overhead of non-information bearing data,

9 said baseband filter being implemented by a digital microcontroller that replaces an
10 original square wave data stream of said baseband data with deterministic transitions that
11 reduce harmonic content and maintain bit widths, regardless of data input frequency.

1 38. The article management system of claim 37, including
2 means in each of said receivers for applying processor intensive clock and data recovery
3 algorithms to facilitate said removal of synchronization data by said filter means at said
4 transmitters.

1 39. The article management system of claim 38, wherein said transmitters and
2 receivers further employ forward error correction coding and space diversity processing to
3 increase the reliability of received data, whereby to further optimize bandwidth reduction by
4 eliminating bandwidth needed for retransmission of corrupted data.

1 **40.** The article management system of claim 37, wherein said digital microcontroller
2 comprises a digital filter that uses sine wave segments for transitions.

1 **41.** The article management system of claim 37, wherein each of said receivers
2 includes means to facilitate recovery of transmitted data without transmitted synchronization
3 information by locating the start of each transmitted data message within a predetermined scant
4 time window without aid from bit synchronization patterns.

1 **42.** The article management system of claim 41, wherein said data recovery means
2 performs said start message start location within said predetermined scant time window by an
3 iterative search that sequentially clocks in the data at greater and greater delays from the
4 nominal message start time until a valid data packet is located.

1 **43.** The article management system of claim 37, wherein each of said transmitters
2 further includes means for performing a bit interleaving pattern on the data to be transmitted
3 to provide a randomization of the data bits to ensure that single bit shifts in received data cause
4 errors in all code words.

1 **44.** The article management system of claim 43, wherein each of said receivers
2 further includes means for de-interleaving received data according to said bit interleaving
3 pattern introduced by said interleaving means at each of said transmitters.

1 **45.** The article management system of claim 37, wherein said wireless network
2 includes a time division multiple access (TDMA) network, and each of said receivers includes
3 means for batch processing of received messages from said transmitters to recover clock and
4 data on a packet by packet basis in said TDMA network.

1 **46.** The article management system of claim 45, wherein said means for batch

2 processing of received messages includes means for delay decoding sampled bits of the received
3 data, with only predetermined allowable bit patterns present in the delay code, whereby if a bit
4 error causes an invalid pattern, the pattern is decoded to one of the possible bits represented
5 by the pattern, and if subsequent error detection processing on the decoded data indicates an
6 error, then, if only one ambiguous data pattern was encountered in that particular code word
7 during the delay decoding process, the other bit value is used and the error detection is
8 repeated, and, if successful, the second bit value is retained.

1 47. The article management system of claim 46, wherein said delay decoding means
2 retains the original value of said one of the possible bits if more than one bit is ambiguous or
3 the second bit also fails to result in valid data, and allows processing to move forward on the
4 premise that the bit error may be correctable at a later stage in the data processing chain.

1 48. The article management system of claim 47, wherein each of said receivers
2 further includes means for de-interleaving received data according to a bit interleaving pattern
3 introduced at each of said transmitters in which the transmitted data is jumbled sufficiently that
4 single bit shifts cause all code words to be in error.

1 49. The article management system of claim 37, including further processing of
2 received data by diversity processing using a combination of error detection and voting.

1 50. A fleet management system for tracking the locations of vehicles in the fleet and
2 determining the status of events related to the usage or function of the vehicles, comprising:
3 navigation apparatus on each vehicle for detecting the location of the vehicle relative
4 to a predetermined reference point,
5 a tracking computer on each of said vehicles for receiving inputs indicative of the
6 location of the vehicle and transmitting navigation and status messages to a fleet management
7 office responsible for the respective transmitting vehicle,

8 at least one non-human sensor on each vehicle for detecting one of said events and
9 supplying an input indicative of the detected event to said tracking computer, and
10 said tracking computer including apparatus for automatic reporting of the detected
11 events to said fleet management office.

1 **51.** The fleet management system of claim 50, wherein said fleet vehicles and said
2 fleet management office are connected for communication by a wireless network.

1 **52.** The fleet management system of claim 51, wherein each vehicle has a plurality
2 of sensors for detecting or measuring various ones of said events and supplying inputs
3 indicative thereof to said tracking computer for prompt reporting of event data as it happens
4 over said wireless network.

1 **53.** The fleet management system of claim 52, wherein at least some of said plurality
2 of sensors are selected from a group consisting of detectors of vehicle ignition, vehicle run
3 time, headlights on, transmission in forward and reverse directions, wheel speed, passenger or
4 driver door open, four wheel drive engagement, vehicle emergency lights or sirens operating,
5 fuel level, coolant temperature, oil pressure, battery voltage, engine warning indications, theft
6 or tamper alarms, cargo door open, cargo temperature, vehicle weight, power takeoff
7 engagement for equipment including pumps, winches, cranes, or augers, engine data bus
8 parameters and tolerance checking, dump box up or hatch open, ready mix drum rotation speed
9 and direction, ready mix wash water usage, ready mix fill water volume, distance traveled
10 between predetermined zones, engine on and off, excessive vehicle speed, driving at improper
11 times, unauthorized stops of vehicle, and arrival/departure times at specified locations.

1 **54.** The fleet management system of claim 51, including apparatus at said fleet
2 management office for correlating a detected event to a vehicle location or vehicle speed.

1 55. The fleet management system of claim 54, wherein said vehicle location
2 correlation apparatus includes means for comparing the vehicle location detected by said
3 navigation apparatus to predetermined geographically mapped zones.

1 56. The fleet management system of claim 51, including apparatus at said fleet
2 management office for defining map regions constituting zones in areas expected to be
3 traversed by said fleet vehicles, and wherein said apparatus for automatic reporting includes
4 using said navigation apparatus of the associated fleet vehicle to report one or more of distance
5 traveled by the vehicle between zones, vehicle engine on and off, vehicle being driven at
6 excessive speed, vehicle being driven at improper times, vehicle making unauthorized stops,
7 and times of arrival and departure at preselected locations.

1 57. The fleet management system of claim 51, wherein said fleet vehicles are
2 ambulances and said automatic reporting reports trips, call times, pick up locations, and
3 hospitals to which deliveries are made to said fleet management office.

1 58. The fleet management system of claim 50, wherein said apparatus for automatic
2 reporting of the detected events reports exceptions to routine operations of the vehicle to said
3 fleet management office.

1 59. The fleet management system of claim 52, wherein said fleet vehicles are ready
2 mix concrete or other slurry material mixer trucks, and said plurality of sensors detect or
3 measure at least some of the events of truck fully loaded at plant site, truck departure from
4 plant site, truck arrival at job site, truck commencing pour, truck pour ended, truck undergoing
5 wash, truck departure from job site, truck arrival at plant site, and deviations from a routine
6 sequence of said events; and at least some of said events are detected based on truck speed or
7 time interval over which an event takes place.

1 **60.** The fleet management system of claim 59, wherein at least some of said mixer
2 trucks of said fleet vehicles are equipped with hall effect sensors that measure both speed and
3 direction of rotation of the mixer drum of the truck.

1 **61.** The fleet management system of claim 50, wherein said fleet vehicles are bulk
2 powdered material transport trucks in which air is pumped through pipes under the bulk hopper
3 of the truck for unloading the powdered material therefrom, and each of said transport trucks
4 includes a tachometer sensor for on/off detection of pumping to indicate unloading and
5 cessation of unloading of powdered material from the respective said transport truck to report
6 same to said fleet management office.

1 **62.** The fleet management system of claim 50, wherein said fleet vehicles are bulk
2 aggregate material transport trucks each having a dumper for unloading the aggregate material
3 therefrom, and each of said transport trucks includes a sensor for detection of dumper
4 operation to indicate unloading and cessation of unloading of aggregate material from the
5 respective said transport truck to report same to said fleet management office.

1 **63.** A fleet management system for a fleet of vehicles, comprising transceivers on
2 said vehicles and in geographically disparate hubs for communication between a fleet
3 management office and said vehicles, a network for said communication, and a central
4 processing unit in each of said transceivers comprising a microprocessor with a time processing
5 unit for performing precise clock synchronization of said transceivers throughout said network.

1 **64.** The fleet management system of claim 63, wherein said network is a wireless
2 network.

65. The fleet management system of claim 64, wherein said wireless network is a
time division multiple access (TDMA) network.